Department of Biosystems
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Biosystems Design Projects

Remediation of Harmful Algal Blooms in Soldan Pond

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Introduction

Soldan Dog Park Pond experiences recurring harmful algal blooms (HABs) that limit recreational use and pose risks to dog and human health.

Frequent HAB events have resulted in periodic pond closures and water quality degradation.

Background

HABs are driven by excess phosphorus from both external loading (stormwater runoff) and internal loading (sediment release).

Low dissolved oxygen (DO < 3 mg/L) triggers sediment phosphorus release, creating a problematic feedback loop: Low DO → P release → algal growth → further hypoxia.

Problem Statement

Internal phosphorus loading persists even if external inputs are reduced, allowing continued algal growth under current DO conditions.

A solution must target both in-pond dissolved oxygen dynamics, and external phosphorus pathways to disrupt this cycle and reduce HAB occurrence. Figure 1 shows HABs on the surface of the pond.

Figure 1. Harmful algal blooms, green layer on top of the water, at the Soldan Dog Pak

Objectives

- Identify and evaluate at least 3 phosphorus mitigation methods including a chemical remedy, a filter treatment, and a biological design
- Develop a watershed model to analyze phosphorus loading, runoff patterns, and treatment designs
- Reduce chlorophyll-a to below 0.03 mg/L in the SDP pond.
- Reduce phosphorus concentrations to <.025 mg/L in the SDP pond.

Constraints

- Spend less than $1,000 on developing design solutions.
- Reliable field sampling is limited to approximately 30 days within acceptable weather conditions.
- Must comply with Michigan Department of Environment, Great Lakes, and Energy (EGLE) part 4 and part 8 water quality standards(Michigan Department of Environment, Great Lakes, and Energy (EGLE), 2025).
- Must avoid activities that could further degrade water quality, wildlife, or public health.

Design Alternatives

Three designs were considered for this project: a biochar system, an aeration system, and use of P-consuming biologicals.

Biochar is a charcoal-like substance that can sorb phosphorus in the water. Biochar is an excellent option for lowering phosphorus levels but needs to be replaced in between uses.

Aeration involves installing pipes that released compressed air bubbles. As the air bubbles rise, they circulate the water and disrupt cyanobacteria growth conditions. Aeration also add more dissolved oxygen into the water, which keeps phosphorus concentrations level.

P-consuming biologicals, such as different kinds of seaweeds and cattails, uptake large amounts of phosphorus, making it unusable to the cyanobacteria.

All three designs were compared against each other using a decision matrix. 5 factors, rated from 1 as the worst and 10 as the best, were used to determine the best design. Factors included cost, cyanobacteria control, pond downtime, maintenance cost, and environmental impact.

Each factor was given a weight showing how important each factor is.

Table 1 shows the final decision matrix.

Table 1. Final design alternatives decision matrix

	Cost	Cyanotoxin Control	Pond Downtime	Maintenance Cost	Environmental Impact	Total Score Multiplied by weight
Factor Weight	.3	.3	.05	.15	.2	
Biochar	6	9	10	6	7	7.3
Aeration	7	7	8	8	10	7.8
P-Consuming Biologicals	3	3	5	5	3	3.4

Selected Design

Selected Design is a two-step design combining both a biochar and aeration system.

Biochar will be applied to the pond to reduce phosphorus levels down to 0.25 mg/L. The Biochar will be applied in chemical pallets tethered to the eastern dock. This would allow for the northern beach to be open to dogs. The tethers commonly come with Biochar pallets sold by companies such as TimberChar. The initial biochar application is in the pond, an aeration system will be installed.

The aeration system will be used once the phosphorus levels have reached our target numbers.

Aeration will add dissolved oxygen into the water, keeping phosphorus levels low.

Testing should be done regularly to monitor phosphorus levels.

If phosphorus levels approach unsafe numbers, biochar can be reapplied on an as needed basis.

Proposed Installation

Figure 2 shows the proposed installation for the aeration system.

Blue dots represent individual aerators.

Red lines are set up and tubing for the system. Number next to the lines show distance from the power source.

The yellow square represents the power source.

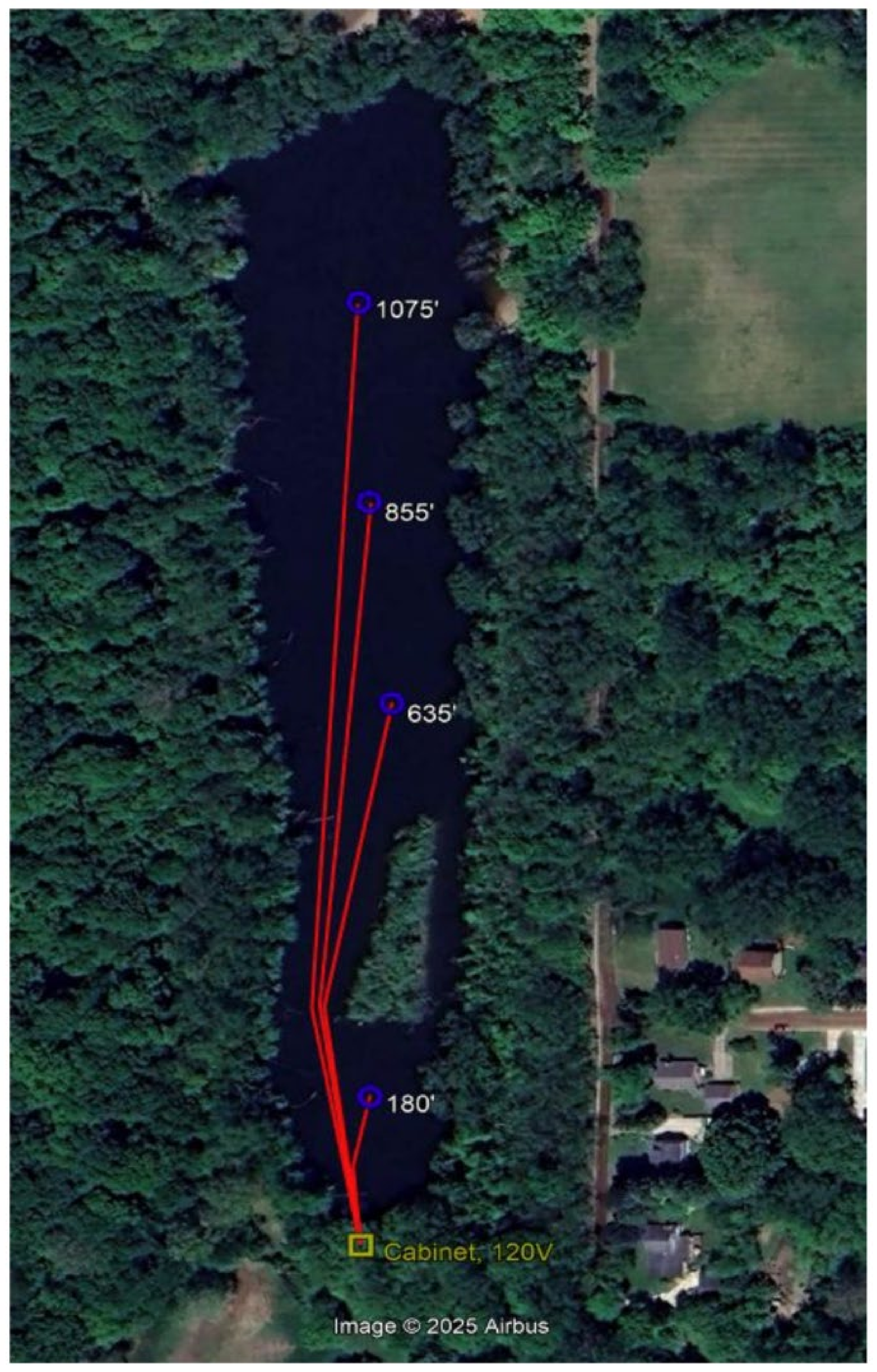

Figure 2. Recommended placement of the diffused aeration units within the Soldan Dog Park

Design Parameters

Figure 3 shows the combined land use map created using ArcGIS.

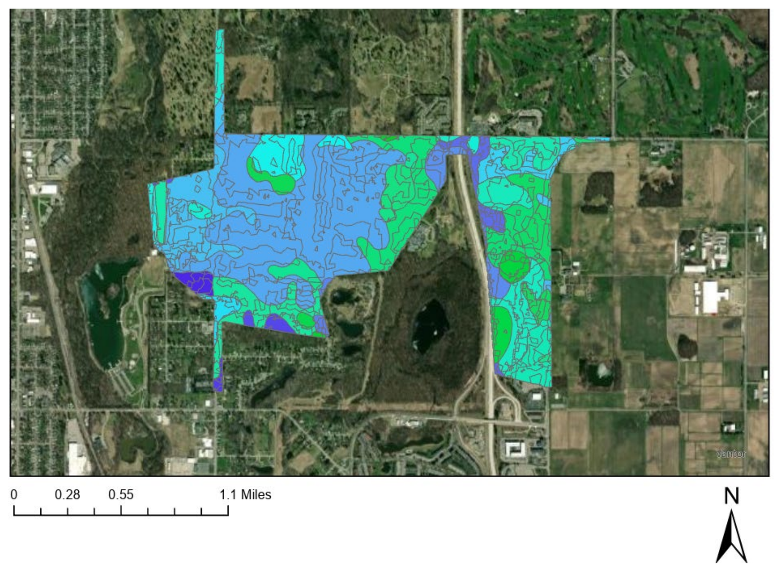

Figure 3. HSG & land use classification of watershed area

Hydrologic soil group and Land use were used to runoff using the SCS CN Method (equations shown below).

$$S = \frac{1000}{CN} - 10\ (inches)$$

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

P = Precipitation (in)
I_a = Initial Abstraction = 0.2S
S = Maximum Retention
Q = Runoff (in)
CN = Curve Number

Hydraulic residence time estimated using drone tracking and flow analysis.

Target conditions: DO = 3-6 mg/L; Total P < 0.025 mg/L; Chlorophyll-a < 0.03 mg/L.

Aeration modeled as oxygen input proportional to (DO_{sat} –DO) with threshold control logic.

Sediment phosphorus release modeled as a function of DO (internal loading increases under low DO).

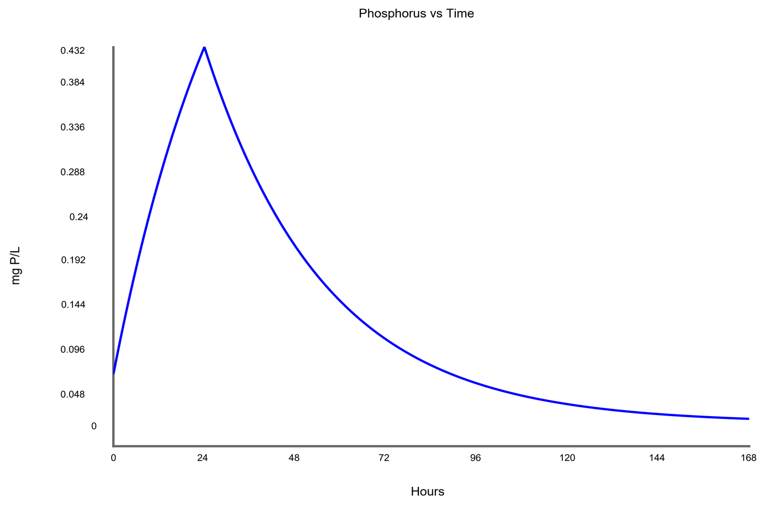

Figure 4. Simulated one year 24-hour storm event and total phosphorus (TP) concentration dynamic over time using STELLA.

Biochar treatment activated when phosphorus exceeds design threshold. Figure 4 is a simulated run of the system using STELLA.

TP spikes rapidly during the 24-hour storm event due to stormwater loading, followed by a gradual decline driven by biological uptake and biochar phosphorus removal.

Economics

The cost of the first application of biochar was calculated using volume of the pond obtained from ArcGIS (48,588,345L), and initial phosphorus concentration obtained from field samples, which was found to be a uniform .077 mg/L.

Initial application was calculated to be $443. Future applications of biochar will be on an as needed basis and can range from $55-$70 per application which would combat the phosphorus loading rate of .15kg-.19kg/year.

A quote of $10,930 for the proposed aeration system was provided by Tri County Aquatics. Electricity costs associated with running the system are $756 per year based on a run cost of $0.18/kWh for 5 months. Table 2 shows cost breakdown of the proposed aeration system.

Product Description	Warranty	Price/Unit	Cost
RobusAire, Includes (2) 1/2HP, 120V, Compressors, 4 Dual-Loop Diffusers, RobustAire Medium Cabinet with Noise Reducing AireGuard Technology, (Tubing Sold Separately)	Compressor: 3 years/Wearable parts 2 years, Tubing: 15 years, Diffuser & Cabinet: Lifetime	$5,976	$5,976
SureSink Weighted Air Tubing, 5/8in x 500', Spool (Does not include fittings)	Tubing: 15 years	$760	3,800
SureSink weighted Air Tubing Kit, 5/8 x 100'	Tubing: 15 years	$161	$482
Barb, Kit, 3/8 MNPT x 5/8 Hose	No Warranty On Parts	$50	$50
Kit, 5/8 hose connector, 10 pack	No Warranty On Parts	$69	$69
Air filter paper element, KM-60/KM-120/KM-200 for RA systems with remote air intake, (used on all PM, BM, or NC system built with the new remote intake post June 2020)	No Warranty On Parts	$14	$14
		Total Cost:	$10,390

Conclusion

- Our group recommends moving forward with the coupled aeration-biochar system.
- Modelling using STELLA proves the effectiveness this design has in reducing and maintaining phosphorus levels below 0.25 mg/L.
- Watershed modeling was preformed to verify where phosphorus is entering the system from.
- The design is economically viable, as prices are reasonable for the park and funding can be provided by the county.

Select References

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U.S. Department of Agriculture, Natural Resources Conservation Service. (n.d.). *Web Soil Survey*. https://websoilsurvey.nrcs.usda.gov/

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